UNIVERSITY OF SOUTH CAROLINA

BIOMASS ENERGY PLANT

STACK TEST SAMPLING PROTOCOL
REVISION 5

February 2008
GEL Engineering, LLC

Prepared for:

University of South Carolina
Environmental Health and Safety
Columbia, SC

Johnson Controls, Inc.
Columbia, South Carolina
Johnson Controls Project No. 5261-0036

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1.0 INTRODUCTION

A source test of the University of South Carolina (USC) biomass gasification unit is required to demonstrate compliance with SC Regulation 61-62.1, Section II(H); SC Regulation 61-62.5, Standards no. 1 and 5.2; and New Source Performance Standard (NSPS 40 CFR 60), Subpart A, General Conditions and Subpart Dc, Small Industrial - Commercial - Institutional Steam Generating Units.

The source tests are to be conducted in accordance with requirements listed in SC Regulation 61-62.1, Section IV, Source Tests. This protocol has been prepared to meet the requirements of these regulations.

2.0 FACILITY INFORMATION

Regulatory Citation	Requirement	Specification
R.61-62.1 Section IV C.1.a	Facility name, address, and telephone number, and name of facility contact.	USC Biomass Energy Facility 1220 Catawba St. Columbia, SC 29201 Thomas Syfert, Phone: 803-777-5269
R.61-62.1 Section IV C.1.a	Technical Contact	Johnson Controls, Inc. Jerry Langely, Phone: 803-929-2602
R.61-62.1 Section IV C.1.b	Facility permit number and source identification number.	1900-0143-CH as amended for ESP addition. Biomass Gasification System
R.61-62.1 Section IV C.1.c	Name, address, and telephone number of the company contracted to perform the source test.	GEL Engineering, LLC 2040 Savage Rd, Charleston, SC (843) 769-7378
R.61-62.1 Section IV C.1.d	Name, address, and telephone number of the laboratory contracted to perform the analytical analysis of the source test samples.	GEL Engineering, LLC 2040 Savage Rd, Charleston, SC (843) 769-7378

3.0 TEST OBJECTIVES

Regulatory Citation	**Requirement**	**Specification**
R.61-62.1 Section IV C.2.a	Description and overall purpose of the tests	The test objectives are to demonstrate compliance with Permit Condition II.D.17, which requires an initial source test to verify emission rates. The following EPA test methods shall be used: Opacity Method 9 PM: Method 5 PM10: Method 201A/202 SO2: Method 6C NOx: Method 7E CO: Method 10 VOC: Method 25A or 18* *Note: Based upon results of the pre-survey of the source. The EPA Method most appropriate will be selected.
R.61-62.1 Section IV C.2.b	Citation of any applicable State or Federal regulation or permit condition requiring the tests.	PM: 40 CFR 60 Subpart Dc SC 61-62.5 Standard 1 PM10: SC 61-62.1 Section II(H) Opacity: 40 CFR 60 Subpart Dc SC 61-62.5 Standard 1 SO2: SC 61-62.5 Standard 1 NOx: SC 61-62.5 Standard 5.2 CO: SC 61-62.1 Section II(H) VOC: SC 61-62.1 Section II(H)
	Data Quality Objectives	EPA test methods are designed to provide high-quality data for determining compliance with Federal and State emission standards. Adherence to the requirements of these methods shall enhance the quality of the data obtained from air pollutant sampling methods. In these and other applications, the principal objective is to ensure the accuracy of the data at the actual emission levels encountered. To meet this objective, the use of EPA traceability protocol calibration gases and measurement system performance tests are required.
R.61-62.1 Section IV B.5, B.6, and F.1	Test Schedule	The test schedule is based on the requirements of SC Regulation 61-62.1 Section IV paragraphs B.5, B.6, and F.1. The test protocol and any amendments to the protocol shall be submitted to DHEC at least 60 days prior to testing. Within 30 days of site-specific test plan receipt, the DHEC shall notify JCI that the plan is approved or denied or shall request additional information. JCI will submit a written report of the final source test results to the Department by the close of business on the 30th day

		following the completion of the test.

4.0 PROCESS DESCRIPTIONS

Regulatory Citation	**Requirement**	**Specification**	
R.61-62.1 Section IV C.3.a	Description of the process including a description of each phase of batch or cyclic processes, and the time required to complete each phase.	Untreated wood waste will be fed by conveyor to three 36 MMBtu/hr gasifiers, and heated in an oxygen deficient environment. This process generates a synthetic gas. The synthetic gas generated will be combusted in a 76 MMBtu/hr oxidizer. The high temperature gases generated by the oxidizer will be used to generate medium pressure steam in the heat recovery boiler. This steam will feed a 1,500 kW back pressure steam turbine generator and discharge to the campus steam system. The nominal power produced will be fed directly to the USC power grid. This is a continuous process. There are no batch or cycle times associated with the process.	
R.61-62.1 Section IV C.3.b	Process design rates and normal operating rates.	Design rates	
		oxidizer output	76 MMBtu/hr
		output from boiler	60,000 lb/hr steam at 615 psia/740 F
		Operating rates	
		oxidizer output	76 MMBtu/hr
		output from boiler	60,000 lb/hr steam at 615 psia/740 F
R.61-62.1 Section IV C.3.c	Proposed operating rate and conditions for the source test.	Minimum of 90% of heat input to boiler = 68.4 MMBtu/hr. Target capacity is 100%, depending on Campus load demands.	
R.61-62.1 Section IV C.3.d	Methods including proposed calculations, equations, and other related information that will be used to demonstrate and verify the operating rate during the source test.	Operating rate during testing will be demonstrated and verified using a mass and heat balance that will be developed for the facility using calibration procedures for in-line process instrumentation.	

4.0 PROCESS DESCRIPTIONS (Continued)

R.61-62.1 Section IV C.3.e	Description of any air pollution control equipment.	An Electrostatic Precipitator (ESP), model no. 11R-1220-2712P, manufactured by PPC Industries will be used to control PM emissions from the system. Unit is designed for 55,800 ACFM, with an outlet emission rate of 0.03 lb/MMBtu of heat input.
R.61-62.1 Section IV C.3.f	Description of any stack gas or opacity monitoring systems.	A Continuous Opacity Monitoring System (COMS) is to be installed on the stack.
R.61-62.1 Section IV C.3.g	Description of all air pollution control monitors (for example, pressure gauges, flow indicators, cleaning cycle timers, electrostatic precipitator voltage meters, etc.) when applicable.	ESP controls monitor ESP secondary voltage, secondary mA and cleaning cycle frequency.

<table>
<tr><td rowspan="13">R.61-62.1
Section IV
C.3.h</td><td rowspan="13">A list of process and air pollution control operating parameters that will be recorded during the tests, the responsible party who will record these readings, and the frequency at which readings will be recorded.</td><td colspan="2">The following process and ESP operating parameters will be collected by operating personnel and recording devices at the intervals noted below.</td></tr>
<tr><td>Parameter</td><td>Frequency</td></tr>
<tr><td>wood feed rate</td><td>Hourly Average. A continuous weigh belt monitor that weighs the bark as it goes into all three gasifiers (total bark flow). The belt monitor will be calibrated before emissions testing.</td></tr>
<tr><td>COMS opacity</td><td>continuous six minute averages</td></tr>
<tr><td>ESP operating voltage</td><td>continuous</td></tr>
<tr><td>ESP operating current</td><td>continuous</td></tr>
<tr><td>ESP pressure drop</td><td>Hourly</td></tr>
<tr><td>generator output</td><td>continuous</td></tr>
<tr><td>Heat Input</td><td>A fuel sample will be collected and submitted for ultimate analysis and calorific value.</td></tr>
<tr><td>steam flow</td><td>Taken every 15 minutes during testing.</td></tr>
<tr><td colspan="2">The following testing parameters shall be collected by the selected stack test sampling company at the intervals shown.</td></tr>
<tr><td>Parameter</td><td>Frequency</td></tr>
<tr><td>stack velocity</td><td>Taken at each traverse point during each EPA Method 5 and 201A test run.</td></tr>
<tr><td>stack temperature</td><td>Taken at each traverse point during each EPA Method 5 and 201A test run.</td></tr>
</table>

5.0 SAFETY CONSIDERATIONS

<table>
<tr><th>Regulatory Citation</th><th>Requirement</th><th colspan="2">Specification</th></tr>
<tr><td rowspan="9">R.61-62.1 Section IV C.4.a</td><td rowspan="9">Identification of any risks associated with sampling location and accessibility, toxic releases, electrical hazards, or any other unsafe conditions, and a plan of action to correct or abate these hazards.</td><td colspan="2">The following risks and safety measures to be taken have been identified for the stack sampling tasks.</td></tr>
<tr><td>Risk</td><td>Safety Measure</td></tr>
<tr><td>Slips and trips</td><td>Housekeeping</td></tr>
<tr><td>Falling debris</td><td>Hard hats, safety shoes</td></tr>
<tr><td>Blowing debris</td><td>Safety glasses</td></tr>
<tr><td>Electrical hazards</td><td>Pre-work identification of potential hazard areas including awareness of static discharge hazard following ESP; approved personnel to make electrical repairs</td></tr>
<tr><td>Falls from sampling platform</td><td>Safety harness</td></tr>
<tr><td>Burns</td><td>Gloves</td></tr>
<tr><td></td><td></td></tr>
<tr><td>R.61-62.1 Section IV C.4.b</td><td>List of all necessary or required safety equipment including respirators, safety glasses, hard hats, safety shoes, hearing protection, and other protective equipment.</td><td colspan="2">The following equipment is required for personnel participating in the stack sampling effort:

hard hat
safety shoes
gloves
safety glasses
safety harness at elevations > 6 ft
hearing protection

The stack testing platform meets OSHA requirements.</td></tr>
<tr><td></td><td>Health and Safety Plan (HASP)</td><td colspan="2">JCI shall require the testing subcontractor supply their own HASP and it will be reviewed to ensure it meets JCI standards. See Appendix A for JCI minimum subcontractor requirements.</td></tr>
</table>

6.0 SAMPLING AND ANALYTICAL PROCEDURES

Regulatory Citation	**Requirement**	**Specification**
R.61-62.1 Section IV C.5.a	Description of sampling methods to be used.	The following EPA Methods will be utilized during this testing event; EPA Method 1; Sampling Location EPA Method 2; Volumetric flow determination. EPA Method 3A; Dry Molecular Weight. Oxygen and Carbon Dioxide. EPA Method 4; Moisture determination. EPA Method 5; Total PM determination. EPA Method 6C; SO2 determination. EPA Method 7E; NOx determination. EPA Method 9; Opacity Observation EPA Method 10; CO determination. EPA Method 25A or 18; VOC determination. EPA Method 201A/202; Determination of PM 10 microns or less and condensable matter. EPA Method 205; Gas Dilution System for Protocol Gases.
R.61-62.1 Section IV C.5.b	Description of analytical methods to be used.	EPA Methods 4, 5, & 201A/202; Samples collected to be weighed using an analytical balance. EPA Methods 3A, 6C, 7E, & 25A; Measuring parameters in a stationary source using continuous instrument analyzers. EPA Method 18; Samples will be analyzed via gas chromatography. Flame ionization detection.
R.61-62.1 Section IV C.5.c	Number of tests to be conducted.	One test at the outlet stack.
R.61-62.1 Section IV C.5.d	Number of runs comprising a test.	Three runs at the outlet stack.
R.61-62.1 Section IV C.5.e	Duration of each test run.	One to four hours for EPA Methods 5 & 201A/202. As per 201A/202, run time will depend on dwell time at each traverse point. Method 5 will be a minimum of 2 hours. EPA Methods 3A, 6C, 7E, 9, 25A, & 18 will be 1-hour in duration.
R.61-62.1 Section IV	Description of minimum sampling volumes for each test run.	EPA Method 201A/202; 32 dry standard cubic feet.

C.5.f		EPA Method 5; 64 dry standard cubic feet. EPA Methods 3A, 6C, 7E, and 25A; NA EPA Method 18; To be determined based upon which parameters will be targeted for analysis.
R.61-62.1 Section IV C.5.g	Location where samples will be recovered.	Clean area away from gasification unit. JCI will provide area based on Sampling Company requirements.
R.61-62.1 Section IV C.5.h	Explanation of how blank and recovery check results and analytical non-detects will be used in final emission calculations.	EPA Methods 5 & 210A/202; Non-detected analytes will be reported as less than the analytical detection limit, and are typically <0.1mg for particulate. EPA Methods 6C, 7E, & 25A; Non-detected analytes will be reported as less than the analytical detection limit, and are typically < 1 ppm EPA Method 18; Per the Method, the results will be corrected for recovery. The detection limit is defined as ½ of the lowest calibration standard. Non-detects will be reported at the detection limit.
R.61-62.1 Section IV C.5.i	Maximum amount of time a sample will be held after collection prior to analysis.	Maximum two weeks.
R.61-62.1 Section IV C.5.j	Method of storing and transporting samples.	Contents of impingers stored in glass or Nalgene containers. Collection filters stored in covered containers. Samples under lock during transportation. Liquid samples will be stored in locked cold storage until analysis.

7.0 SAMPLING LOCATIONS AND DOCUMENTATION

Regulatory Citation	**Requirement**	**Specification**
R.61-62.1 Section IV C.6.a	Schematics of sampling sites (include stack dimensions and distances upstream and downstream from disturbances).	There are four sampling ports, oriented at 90 degrees apart. These are located 12'–9" from the nearest "A" obstruction, and 51'-2" from the nearest "B" obstruction. For the 4 ft diameter stack, this is 3.18 stack diameters upstream and 12.8 stack diameters downstream. See Figure 1.
R.61-62.1 Section IV C.6.b	A description of all emission points, including fugitive emissions, associated with the process to be tested, and when applicable, the method that will be used to measure or include these emissions during the source test.	There are no fugitive emissions associated with the ESP, heat recovery boiler, oxidizer, or gasifiers.
R.61-62.1 Section IV C.6.c	Procedure for verifying absence of cyclonic or non-parallel stack gas flow.	An EPA Method 2 test (according to Section 11.4 or 11.5) shall be run prior to testing. An established velocity profile verifies the absence of cyclonic or non-parallel stack gas flow.

8.0 INTERNAL QUALITY ASSURANCE/QUALITY CONTROL MEASURES

Regulatory Citation	Requirement	Specification
R.61-62.1 Section IV C.7.a	Citation of the QA/QC procedures specified in the EPA Reference Methods and the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III.	All field, laboratory, and calibration procedures appearing in CFR 40 Part 60 Appendix A, EPA Sampling Methodologies, and the Quality Assurance Handbook for Air Pollution Measurement Systems Volume III (EPA 600/R-94/038C) shall be followed.
R.61-62.1 Section IV C.7.b	Chain-of-custody procedures and copies of chain-of-custody forms.	The selected sampling company shall be required to follow Air Pollution Training Institute Course 443 "Chain of Custody" Guidebook. A copy of the Chain of Custody form shall be provided from GEL Engineering, LLC.
R.61-62.1 Section IV C.7.c	Procedure for conditioning particulate matter filters (before and after source testing).	Pretest filters will be desiccated for a minimum of 24 hours prior to weighing. Post test filters wills be treated in the same manner, or alternatively oven-dried at 220 degrees F for 2-3 hours, and then desiccated for at least 2 hours.
R.61-62.1 Section IV C.7.d	Procedure for conducting leak checks on vacuum lines, pitot tubes, flexible bags, orsats, etc.	EPA Methods 2, 3, 4, 5, and 201A/202 Quality Assurance procedures for leak checks, data sheets, etc. will be followed as per the reference method and the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III.
R.61-62.1 Section IV C.7.e	Equipment calibration frequencies, ranges, and acceptable limits.	Typical calibration procedures are as follows: Dry Gas Meters: complete calibration after each field use. Post-test calibration must be within 5% of pre-test calibration. Pitot Tubes: complete calibration according to EPA Method 2, section 4.1, annually. Visually inspected prior to each field use. Following each field use, the procedure in sections 4.1.6.2.1 - 4.1.6.2.2 shall be followed. Thermometers: complete calibration on dry gas meter, impinger, stack gas, and probe thermometers annually. Checked after each field use at a temperature within 10% of

Regulatory Citation	**Requirement**	**Specification**
		average measured temperature. Must be within 1.5% of this reference temperature per Section 4.3 of EPA Method 2.
R.61-62.1 Section IV C.7.f	Minimum detection limits of analytical instrumentation.	Typical limits include: • Weighing balances measure to within 0.1 gram for silica gel containers. • Graduated cylinder accuracy is 1 ml for moisture determinations. • The analytical detection limit for each Method to be used shall be provided by the selected sampling company.**
R.61-62.1 Section IV C.7.g	Names, addresses and responsible persons of all sub-contracting laboratories and a description of analytical methods to be used, chain-of-custody procedures and QA/QC measures.	GEL Engineering, LLC 2040 Savage Road Charleston, S.C. 29407 (843) 769-7378
R.61-62.1 Section IV C.7.h	QA/QC measures associated with the collection and analysis of process or raw material samples and the frequency at which these samples will be collected.	Operating personnel will perform proximate analysis per ASTM procedures on fuel feed during all stack tests and ultimate analysis will be carried out on select tests.
R.61-62.1 Section IV C.7.i	Methods for interference and matrix effects checks, and number of replicate analyses.	Interference and matrix effects checks shall be performed as required by the sampling methods specified.
R.61-62.1 Section IV C.7.j	Methods and concentrations for internal standards (standards	NA

Regulatory Citation	Requirement	Specification
	additions prior to extraction).	
R.61-62.1 Section IV C.7.k	Methods and concentrations for surrogate standards (standards additions to collection media prior to sampling).	NA
R.61-62.1 Section IV C.7.l	Methods for recovery checks, field blanks, lab blanks, reagent blanks, proof rinse blanks, and analytical blanks.	A field blank of Acetone will be collected and analyzed as per EPA Methods 5 and 201A for blank correction of probe rinse samples. Method 18 samples will be spiked with approx. 40-60% of the observed concentration for each compound - for non-detects, approx. 5 times the detection limit.
R.61-62.1 Section IV C.7.m	Proposed range of recoveries for data acceptability and method of data interpretation if sample recovery is not within the proposed range.	The normal acceptable range of recovery for Method 18 samples is 70 - 130%. If recoveries fall outside of this range, the cause will be investigated, evaluated and the effect on the data quality presented and discussed in the report.

9.0 FINAL TEST REPORT CONTENT

Regulatory Citation	Requirement	Specification
R.61-62.1 Section IV C.8.a	Final report outline.	GEL Engineering, LLC's standard report format (in compliance with standard EPA format) shall be used. Minimum contents of report to include: I. Certification of results II. Summary of results III. Comparison of results to regulatory standards IV. Test methods and comments on deviations of methods V. Calculations and error summary VI. Raw data sheets/test records

R.61-62.1 Section IV C.8.b	Example calculations when using alternative test methods or for calculation of process operating rates.	No alternative test methods to be used.
R.61-62.1 Section IV C.8.c	Proposed report submission date if more than 30 days after the source test will be needed to complete the report.	Within 30 business days after the source test.

FIGURE 1

SAMPLE PORT LOCATION

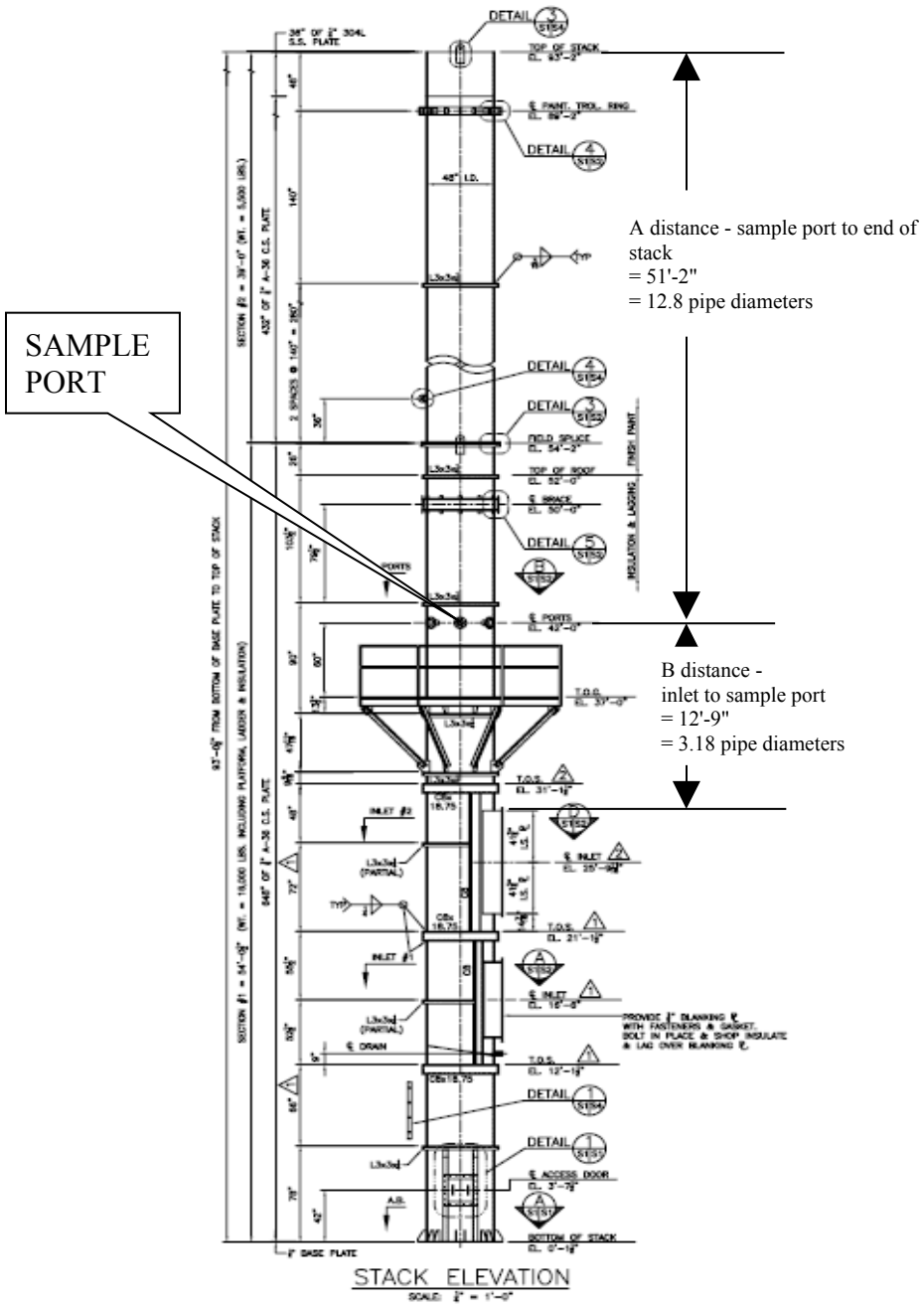
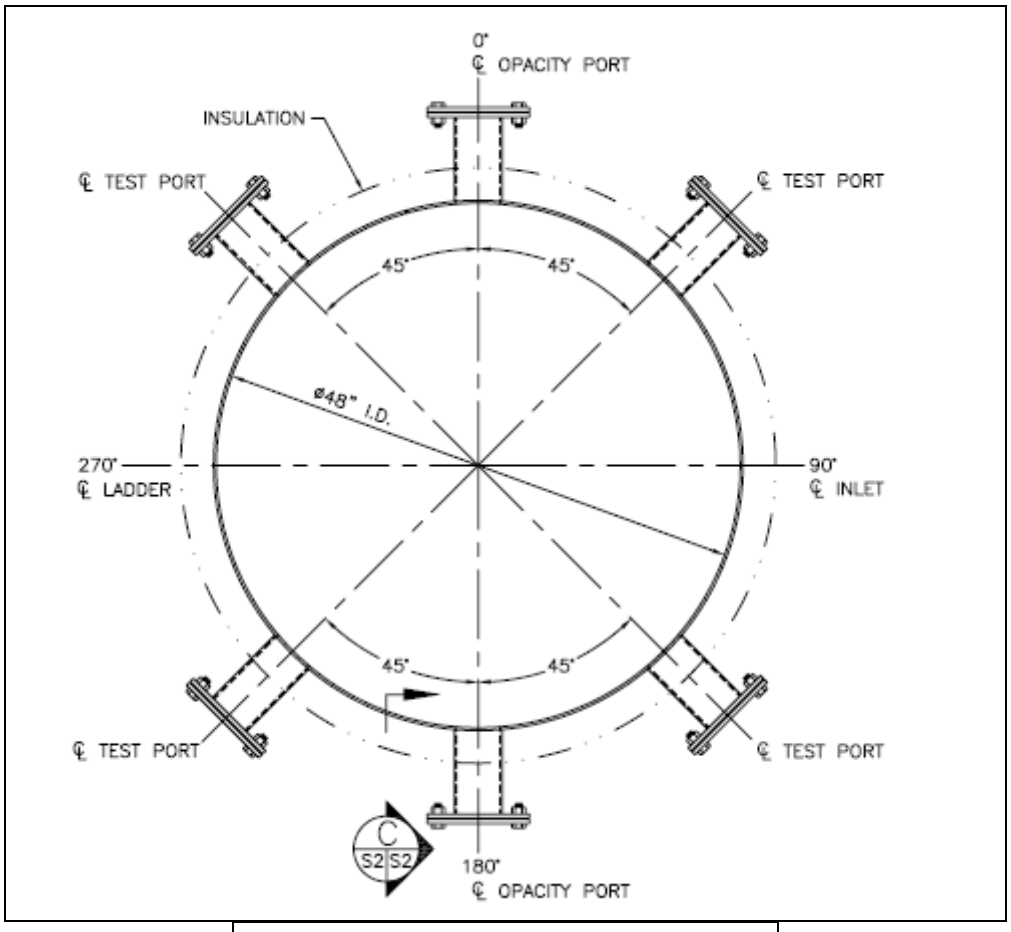


Figure 2

Sampling Port Detail



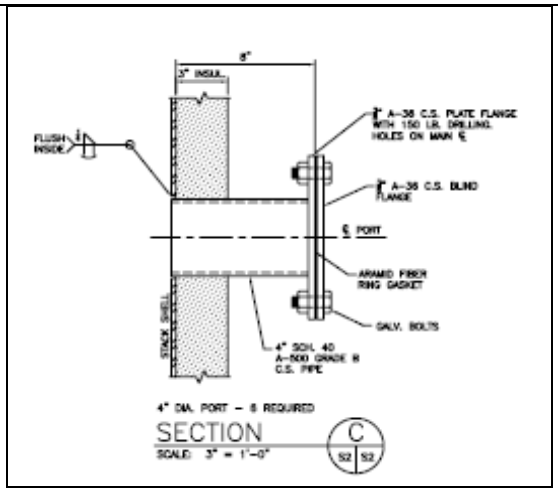


Figure 3

Sampling Platform Detail

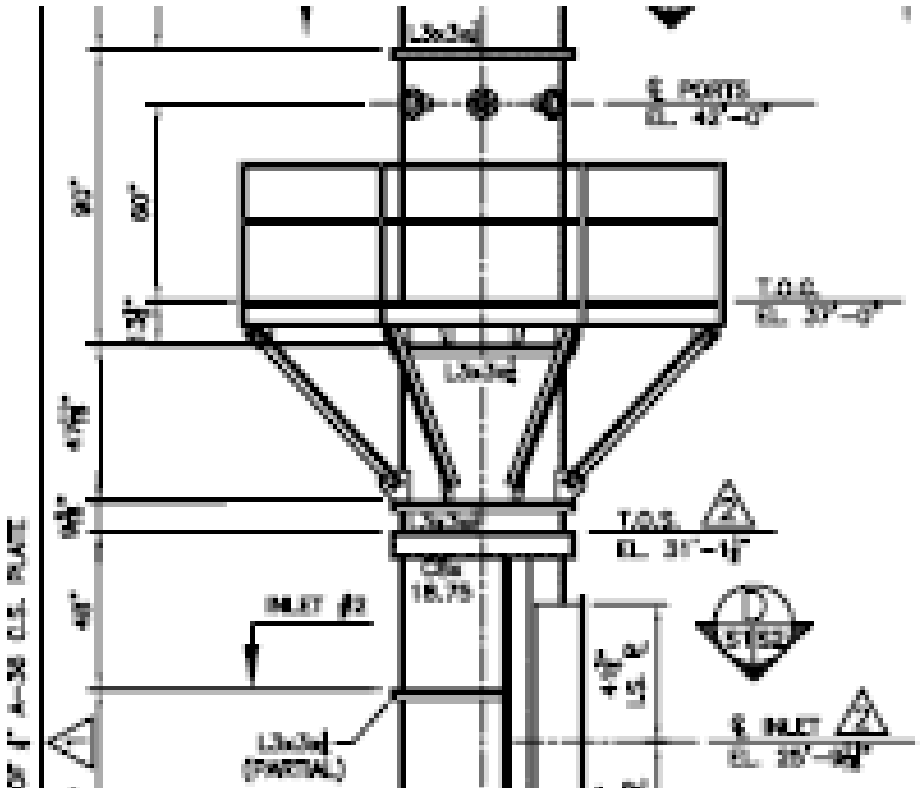
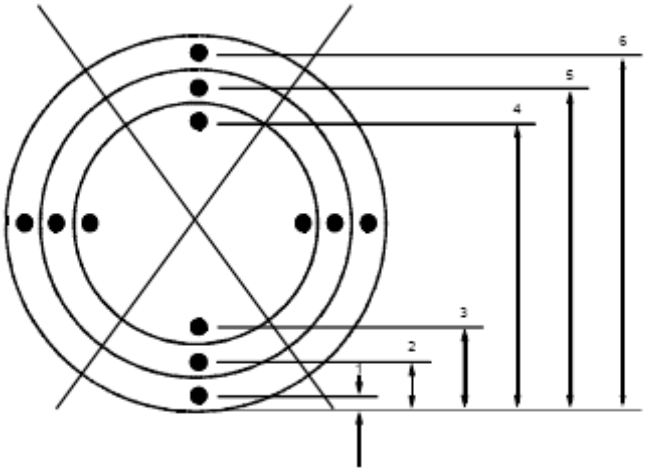


Figure 4

Traverse Points – 48" ID Duct
Generic Drawing from EPA Test Methods
24 traverse points will likely be required with 12 points in each of two traverses at 90 degrees to each other.



Traverse point no	% of stack diameter from inside wall to traverse point	Distance from inside stack wall (inches)
1	2.1	1.01
2	6.7	3.22
3	11.5	5.52
4	17.7	8.5
5	25.0	12.0
6	35.5	17.04
7	64.4	30.91
8	75.0	36.0
9	82.3	39.5
10	88.2	42.34
11	93.3	44.78
12	97.9	46.99

From EPA Method 1

APPENDIX A

JCI CONTRACTOR SAFETY SPECIFICATIONS

1. A workers' compensation Experience Modification Rate of 1.0 or lower (eg. 0.90).
2. A Lost Workday Incident Rate equal to or less than 3.0.
3. A Recordable Incident Rate equal to or less than 7.8.
4. No more than three serious OSHA violations in the last three year period.
5. A documented safety program that meets USC and JCI requirements applicable to the contractor's work.
6. Supporting safety information verifying the contractor's ability to comply with applicable JCI safety requirements and performance criteria (eg. training records, job hazard analyses, etc.).

Contractors with safety records exceeding one or more of the first four criteria may be considered an unnecessary risk and disqualified. These contractors are required to submit a complete copy of their safety program, including OSHA logs , certificate of insurance , and business license for review as well as any other related documentation requested for further evaluation.

APPENDIX B

CITATION OF EPA TEST METHODS

Method 1	SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES
Method 2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
Method 3A	DETERMINATION OF OXYGEN AND CARBON DIOXIDE CONCENTRATIONS IN EMISSIONS FROM STATIONARY SOURCES (INSTRUMENTAL ANALYZER PROCEDURE)
Method 4	Determination Of Moisture Content In Stack Gases
Method 5	Determination Of Particulate Matter Emissions From Stationary Sources
Method 6C	Determination Of Sulfur Dioxide Emissions From Stationary Sources (Instrumental Analyzer Procedure)
Method 7E	Determination Of Nitrogen Oxides Emissions From Stationary Sources (Instrumental Analyzer Procedure)
Method 9	Visual Determination Of The Opacity Emissions From Stationary Sources
Method 10	Determination Of Carbon Monoxide Emissions From Stationary Sources
Method 18	Measurement of Gaseous Organic Compound Emissions By Gas Chromatography
Method 25A	Determination Of Total Gaseous Organic Concentration Using A Flame Ionization Analyzer
Method 201	Determination Of PM10 Emissions (Exhaust Gas Recycle Procedure)
Method 201A	Determination Of PM10 Emissions (Constant Sampling Rate Procedure)
Method 202	Determination of Condensable Particulate Emissions from Stationary Sources